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Effect of Garlic Extract and Mineral Oil Spray on Flowering, Harvesting Time, Yield and Fruit Quality of Peach (*Prunus persica*) Trees cv. 'Florida prince'

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ABSTRACT

This investigation was carried out during two successive seasons on six years-old peach trees cv. 'Florida prince' grown in the Nubaria district, Behera Governorate, Egypt, to study the effect of garlic extract and mineral oil spray on flowering, harvesting time, yield and fruit quality attributes. Trees were sprayed once at the dormant bud stage after winter pruning (mid-November) to run-off with 1, 2 and 4% (v/v) of garlic extract and 2% mineral oil alone or in combinations. The following data was determined: flowering time (full bloom), harvesting percentage at 5-day intervals with four harvests, yield, average fruit weight, volume, and diameter, fruit firmness, percentages of seed/fruit and flesh/fruit weight, total soluble solids (TSS), titratable acidity (TA), total sugars, total chlorophyll and anthocyanin contents. 4% garlic extract advanced full bloom by 20 and 16 days, increased yield by about 57 and 37% and also advanced the beginning of harvest time by about 5 and 10 days than the control in the first and second seasons, respectively. Fruits obtained from trees sprayed with 4% garlic extract had the heaviest and largest fruits with the highest TSS and the lowest TA than other treatments in both seasons.

Keywords: acidity, anthocyanin, fruit firmness, fruit weight, full bloom, total chlorophyll, total soluble solids, total sugars

INTRODUCTION

Peach is one of the most important deciduous fruit crops. In Egypt, the common peach cultivar grown at Noubaria district is cv. 'Florida prince'. Early harvest accompanied with high fruit quality for this cultivar is of high importance for fruit growers either for exportation or the local market demands, thus obtaining the benefit of higher prices. In this respect, the use of dormant breakers is now a common horticultural practice for early harvest and improved fruit quality in peach orchards. In conventional agriculture, the application of hydrogen cyanamide and or/calcium cyanamide are effective chemical agents used for inducing bud breaking among several species of deciduous plants (Lavee and May 1997).

However, the use of natural products in horticultural practices instead of other synthetic chemical products is becoming a main target for many fruit crop producers, where, the world market has been growing rapidly in recent years for organic fruit production (Dimitri and Oberholtzer 2006).

Nevertheless, chemical bud break agents are not authorized for use in organic cultivation (Arispuro *et al*. 2008). In this respect, chemical analyses of garlic cloves have revealed an unusual concentration of sulfur compounds 1-3% (Koch and Lawson 1996). The active substances in garlic responsible for breaking bud dormancy in grapevines (*Vitis vinifera* L. cv. 'Muscat of Alexandria' and *V. vinifera* X *V. labruscna* Bailey cv. 'Kyoho') are sulfur compounds; the effects of the active substances on bud break in varied among the concentrations and the duration of exposure (Kubota *et al*. 1999). Substances with sulfur molecules interrupt the dormancy of different species of deciduous plants (Hartmann *et al.* 2000). The action mechanism of dormancy-breaking compounds has been investigated; a sharp increase in respiration rate was observed within 15 hr after H_2S, allyl sulfide or garlic vapour treatment of dormant tubers of platycodon (*Platycodon grandiflorus*) (Hosoki *et al.* 1985).

Previous reports stated that garlic (*Allium sativum* L.) extracts or paste prepared from fresh garlic induces breaking of dormancy in a manner similar to calcium cyanamide when applied to grapevine and apple (Kubota *et al*. 2000; Serag El-Deen 2002; Botelho and Muller 2007).

In the present study, garlic extract (GE) and mineral oil were evaluated as bud breakers in peach trees cv. 'Florida prince' to obtain early flowering and harvest with highly desirable fruit quality.

MATERIALS AND METHODS

The present investigation was carried out during two successive seasons 2005-2006 and 2006-2007 on cv. 'Florida prince' peach budded on 'Nemagard' rootstock, grown at a private orchard located at El-Nubaria district, El-Behera Governorate, Egypt. Trees were six years old, planted 7.0 × 3.5 m apart in a sandy soil. Trees received the same cultural practices including: drip irrigation, fertilization, pruning as well as pest and disease control. Twenty-four trees uniform in vigor and size as possible were selected for this study. All trees received the same volume of the spraying solution.

The experiment included eight spraying treatments as follows: 1) Control (sprayed with water); 2) 2% MO (MO = Alpoluom®, 80% mineral oil, Kafr El-Zayat Pesticides and Chemicals Co., Al-Gharbiya Governorate, Egypt); 3) 1% GE (1 mL/100 mL); 4) 2% GE; 5) 4% GE; 6) 1% GE + 2% MO; 7) 2% GE + 2% MO; 8) 4% GE + 2% MO.

The experimental trees were arranged in a randomized complete block design and sprayed once at dormant bud stage (mid November) during the two seasons of study.

The GE was prepared from 100 g of fresh Egyptian white garlic (*Allium sativum* L.) peeled cloves, mashed in a porcelain mortar (Kubota and Miyamuki 1992), then crushed in 0.5 L distilled water using a mixer, filtered and decanted by distilled water to 1 L

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to obtain 10% GE that was diluted to get 1, 2 and 4% (v/v).

During both seasons data were recorded for the following parameters:

a) Full bloom: period in days beginning from time of spray (15/11) to full bloom, (50% flowering), according to Shaltout (1987).

b) Accumulative harvested fruits (%) every 5 days during four harvest times as follows: Number of fruits picked each time/Total number fruits × 100

c) Yield: Number of fruits/tree at harvest times at 10, 15, 20, and 25 of April during 2006 and 15, 20, 25 and 30 of April during 2007 seasons.

d) Yield (kg/tree), calculated as follows:

Total number of fruits/tree at harvest times × average fruit weight.

e) Fruit quality: A sample of 10 fruits was randomly taken during harvests on the 25th April in 2006 and on the 30th April in 2007 to determine:

i. Physical characteristics

Average fruit weight (g), average fruit size (cm^3) and fruit diameter (cm) were determined by ordinary methods. Fruit firmness was determined as ($lb/inch^2$) by using a Magness pressure tester (with a 5/16 plunger).

Flesh weight (%) = Fruit weight – seed weight/Fruit weight × 100

Seed weight (%) = Seed weight/Fruit weight × 100

ii. Chemical characteristics

Total soluble solids (TSS%), total acidity (%),total sugars (%) and TSS/acid ratio were determined according to A.O.A.C. (1985). Total chlorophyll was determined using a spectrophotometer (Model 1601 PC UV-Visible spectrophotometer, Shimadzu, Kyoto, Japan) as described by Wettstein (1957). Anthocyanin was determined by a spectrophotometer as described by Hsia *et al.* (1965).

Statistical analysis

The obtained data were subject to analysis of variance and the least significance difference (L.S.D.) at 5% was used for comparing differences between treatments according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Full bloom

Data in **Figs. 1** and **2** shows that most treatments, especially those that included GE at a high concentration caused a great impact on earliness of flowering. 4% GE showed superiority in earliness of full bloom over all other treatments during both seasons, and that such a treatment advanced full bloom time significantly more than the other treatments in both seasons, except for the 4% GE + 2% MO treatment, where no significance was observed in the second season.

This means that peach trees cv. 'Florida prince' reached full bloom in response to 4% GE 20 and 16 days earlier than control trees in the first and second season, respectively. This proves that full bloom of peach trees was advanced with increasing GE concentration either sprayed individually or combined with MO.

The earliness of flowering in trees sprayed with GE at a high concentration may be explained due to the advanced bud break and consequently advanced full bloom, this response coinciding with that observed by Hosoki *et al.* (1984) who found that fresh garlic paste resulted in early flowering of peony tree (*Paeonia suffruticosa*) when applied to dormant buds. These results also agree with those of Serag El-Deen (2002) who found that vines treated with GE bloomed about 4-6 days earlier than the control. Similarly, Botelho *et al.* (2007) found that 1.5 or 3% GE spray improved and advanced bud sprouting of grapevine cuttings over the control. Also, the results are in harmony with those obtained by Botelho and Muller (2007) who found that the application of 10% GE + 2% MO was effective in advancing bloom of

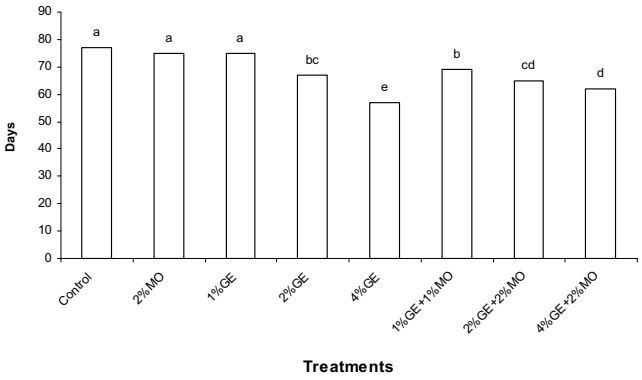

Fig. 1 Effect of garlic extract and mineral oil spray on full bloom time (in days) of peach trees cv. 'Florida prince' in the 2006 season.

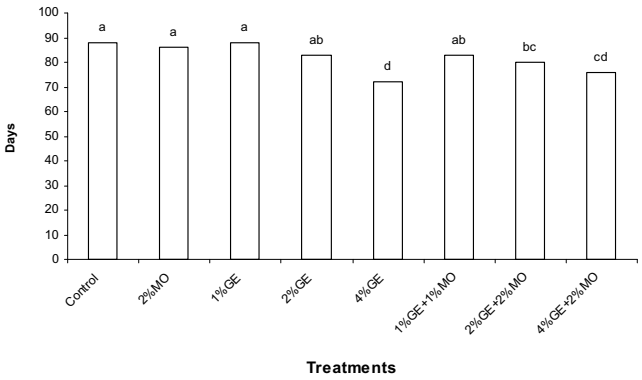

Fig. 2 Effect of garlic extract and mineral oil spray on full bloom time (in days) of peach trees cv. 'Florida prince' in the 2007 season.

'Royal Gala' apple trees and Arispuro *et al.* (2008) who reported that the products derived from garlic-advanced bud breaking in grapes cv. 'Flame Seedless' by about 14-16 days in relation to the control.

Harvest time

Concerning harvest time, data in **Figs. 3** and **4** indicates that most treatments significantly advanced harvest time compared with the control in both seasons. It is also noticeable that GE at a high concentration showed superiority over other treatments. In 2006 season, 4% GE resulted the highest picking percentage during the harvest periods (10/4, 15/4, 20/4 and 25/4) where it recorded 21.3, 62.8, 86.2 and

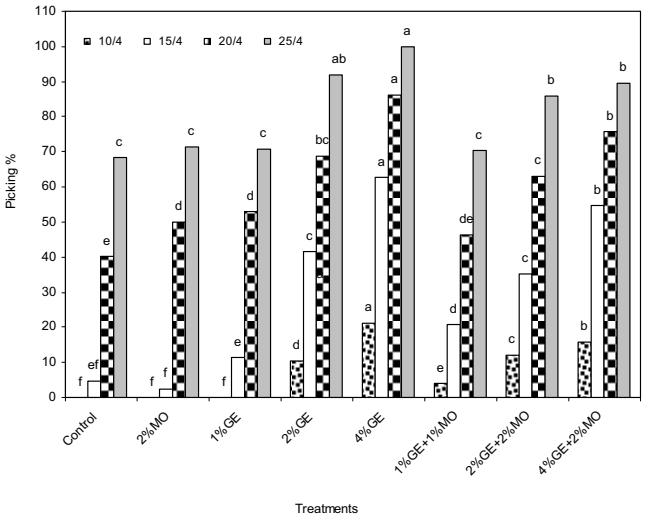

Fig. 3 Effect of garlic extract and mineral oil spray on fruit accumulative picking % of peach trees cv. 'Florida prince' during harvest periods in the 2006 season.

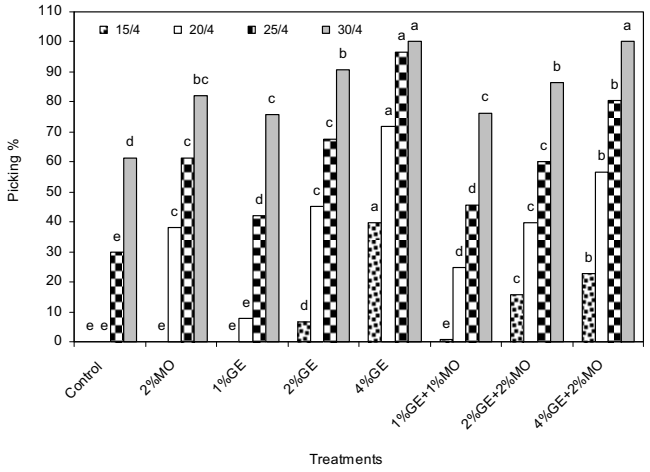

Fig. 4 Effect of garlic extract and mineral oil spray on fruit accumulative picking % of peach trees cv. 'Florida prince' during harvest periods in 2007 season.

100% compared with the control which recorded 0.0, 4.7, 40.2 and 68.4% during the same harvesting periods, respectively. A similar trend was observed in the second season. It is clear from the obtained results that increasing GE concentration was positively related with an advance in harvest time. These results are in agreement with those found by Serag El-Deen (2002) who mentioned that 10 and 20% GE application were significantly effective in advancing harvesting date of 'Thompson seedless' grape (*Vitis vinifera* L.) than the control.

However, the advance in harvest and also the high percentage of accumulative picked fruits were obtained when 4% GE was used in all four harvests, reflected positively on the shortening of the harvest time (in days) than other treatments. Kubota *et al*. (2000) found that GE advanced bud break of grapevines (*Vitis vinifera* X *Vitis labruscana*, cv. 'Pione' and *Vitis vinifera* cv. 'Thompson seedless') significantly and caused uniformity in bud break, but the effectiveness varied according the concentration.

Yield

Results in **Table 1** show that all treatments decreased the number of fruits per tree compared with the control. However, yield (kg/tree) increased significantly in all treatments except for 2% MO which decreased yield more than the control in both seasons.

Table 1 Effect of garlic extract and mineral oil spray on yield as number and weight (kg/tree) of peach trees cv. 'Florida prince' during harvest periods in 2006 and 2007 seasons.

Treatments	Fruit No. /tree		Yield (kg/tree)	
	2006	2007	2006	2007
1- Control	385.67 a	451.33 a	30.59 ef	34.73 d
2- 2%MO	269.00 e	320.67 e	26.36 g	27.44 f
3- 1%GE	341.67 b	417.00 b	35.60 bc	44.90 b
4- 2%GE	334.00 bc	390.67 c	37.31 b	42.44 c
5- 4%GE	332.67 bc	356.67 d	48.14 a	47.44 a
6- 1%GE + 2%MO	297.00 d	327.33 e	30.30 f	32.62 e
7- 2%GE + 2%MO	303.33 d	353.33 d	32.45 de	33.19 de
8- 4%GE + 2%MO	314.67 cd	353.67 d	33.65 cd	43.48 bc
LSD at 0.05 %	21.747	14.115	2.140	1.821

Means having the same letter (s) within a column are not significantly differ at 5% level

Highest yields (48.1 and 47.4 kg/tree) were obtained from trees sprayed with 4% GE in the first and second season, respectively. Results indicate that the presence of MO with GE at any concentration significantly decreased yield more than GE sprayed alone.

These results are in agreement with previous findings on grapes reported by Serag El-Deen (2002) who found that GE application at 10% was significantly effective in increasing the yield of 'Thompson' seedless grapes by 51.6 and 33% more than the control in the first and second seasons, respectively.

Fruit quality

Results in **Tables 2** and **3** show the effect of GE and MO spray on some physical and chemical fruit characteristics of peach trees cv. 'Florida prince' during 2006 and 2007 seasons.

All treatments significantly increased fruit weight compared with the control in both seasons. GE at 4% recorded the highest fruit weight values (144.67 and 133.0 g) compared with the control (79.38 and 77.0 g) in the first and second seasons, respectively. Other treatments exhibited intermediate fruit weight values.

Concerning fruit size, all treatments resulted in significantly larger fruit than the control; the largest fruit was obtained with 4% GE. However, the increase in fruit size in response to any of the remaining treatments was significant in both seasons compared with the control, except for 2%

Table 2 Effect of garlic extract and mineral oil spray on some physical fruit characteristics of peach trees cv. 'Florida prince' in 2006 and 2007 seasons.

Treatments	Fruit weight (g)	Fruit size (cm^3)	Fruit diameter (cm)	Fruit firmness ($lb/inch^2$)	Flesh weight/fruit weight (%)	Seed weight/fruit weight (%)
2006						
1- Control	79.38 d	80.67 e	4.97	16.43 a	87.80 a	12.20 d
2- 2% MO	98.22 c	105.00 d	5.33	15.33 c	86.90 b	13.10 c
3- 1% GE	104.49 bc	118.70 b	5.43	15.97 b	87.57 ab	12.43 cd
4- 2% GE	111.80 b	108.03 cd	5.40	14.53 d	87.37 ab	12.63 cd
5- 4% GE	144.67 a	138.73 a	6.10	12.50 f	83.93 c	16.07 b
6- 1% GE + 2% MO	102.06 c	103.30 d	5.43	15.60 bc	86.80 b	13.20 c
7- 2% GE + 2% MO	107.03 bc	113.87 bc	5.47	14.30 d	84.20 c	15.80 b
8- 4% GE + 2% MO	106.94 bc	107.47 cd	5.27	13.53 e	83.03 d	16.97 a
LSD at 0.05 %	9.681	7.723	N.S	0.399	0.797	0.797
2007						
1- Control	77.00 g	78.83 d	5.00 e	16.00 a	90.70 a	9.30 e
2- 2% MO	85.60 f	85.80 d	5.40 cd	14.80 b	86.17 cd	13.83 bc
3- 1% GE	107.70 c	110.70 c	5.63 c	15.87 a	87.63 bc	12.37 cd
4- 2% GE	108.70 c	108.70 c	6.00 b	14.07 c	89.13 ab	10.87 de
5- 4% GE	133.00 a	136.47 a	6.33 a	12.13 e	84.77 de	15.23 ab
6- 1% GE + 2% MO	99.73 d	107.43 c	5.30 d	15.03 b	87.77 bc	12.23 cd
7- 2% GE + 2% MO	94.00 e	104.80 c	5.60 c	14.10 c	84.07 e	15.93 a
8- 4% GE + 2% MO	123.00 b	124.13 b	6.03 b	13.20 d	84.10 e	15.90 a
LSD at 0.05 %	0.525	0.015	4.027	0.015	0.015	2.639

. Means having the same letter (s) within a column are not significantly differ at 5% level

Table 3 Effect of garlic extract and mineral oil spray on some chemical fruit characteristics of peach trees cv. 'Florida prince' in 2006 and 2007 seasons.

Treatments	T.S.S (%)	Acidity (%)	Total sugars (%)	Chlorophyll (%)	Anthocyanin OD *	T.S.S/ acid ratio
1- Control	9.83 e	0.46 a	43.20 e	0.60 a	0.41 ?	21.37 d
2006						
2- 2% MO	10.03 de	0.44 ab	45.57 d	0.58 b	0.38?	22.80 d
3- 1% GE	10.40 d	0.44 b	50.43 c	0.56 c	0.41?	23.64 d
4- 2% GE	11.80 c	0.41 c	50.73 bc	0.53 d	0.42?	28.78 c
5- 4% GE	13.87 a	0.37 d	54.53 a	0.43 g	0.45?	37.49 a
6- 1% GE + 2% MO	11.47 c	0.41 c	46.13 d	0.49 e	0.44?	27.98 c
7- 2% GE + 2% MO	12.43 b	0.39 d	50.37 c	0.44 fg	0.44?	31.87 b
8- 4% GE + 2% MO	13.40 a	0.38 d	52.70 ab	0.45 f	0.42?	35.26 a
LSD at 0.05%	0.476	0.021	2.206	0.015	N.S	2.628
2007						
1- Control	8.93 e	0.47 a	42.83 f	0.58 a	0.33 f	19.00 e
2- 2% MO	9.87 d	0.44 b	44.30 ef	0.55 b	0.35 e	22.43 d
3- 1% GE	10.83 c	0.41 c	50.83 cd	0.53 c	0.37 d	26.41 c
4- 2% GE	11.63 b	0.38 d	53.43 bc	0.51 d	0.38 d	30.61 b
5- 4% GE	13.53 a	0.33 e	58.13 a	0.44 e	0.43 b	41.00 a
6- 1% GE + 2% MO	10.47 c	0.41 c	48.10 de	0.53 c	0.37 d	25.54 c
7- 2% GE + 2% MO	11.90 b	0.37 d	55.00 ab	0.50 d	0.40 c	32.16 b
8- 4% GE + 2% MO	13.50 a	0.33 e	58.60 a	0.44 e	0.45 a	40.91 a
LSD at 0.05%	0.525	0.015	4.027	0.015	0.015	2.639

*: Optical density
Means having the same letter (s) within a column are not significantly differ at 5% level

MO, which was not significantly different in the second season.

Fruit diameter was improved by different treatments. Highest fruit diameter was obtained from 4% GE, followed by 4% GE + 2% MO, 2% GE + 2% MO and 1% GE + 2% MO in descending order. The differences among fruit diameter means corresponding to those four treatments were significant in the second season only.

Generally, all treatments significantly decreased fruit firmness in the two seasons compared to the control. There was a direct proportional relationship between the concentration of GE spray applied alone or combined with MO and fruit firmness: the lower the GE concentration, the firmer the fruit.

Flesh weight percent decreased in to all tested treatments compared with the control, except for fruits obtained from tress sprayed with GE at the lower concentrations in 2006, and in 2007.

All treatments increased seed weight % significantly compared with the control. However, seed weight % increased proportionally with increasing GE concentration: the higher the GE concentration, the higher the seed weight %.

Data in **Table 3** shows that all treatments significantly increased the percentage of total soluble solids (TSS) compared with the control.

In both seasons, the high TSS% resulted from 4% GE and 4% GE + 2% MO, followed in descending order by 2% GE, 1% GE, 2% GE + 2% MO and 1% GE + 2% MO. The use of MO with GE sprays had no noticeable effect on TSS% compared with GE sprays alone. Moreover, it is obvious that TSS% tended to increase due to increasing GE concentration.

The acidity % of all treatments decreased significantly compared with the control. The least acidic value was obtained from GE at 4%. However, the higher the GE concentration, the lower the fruit acidity. This was true for either GE sprayed alone or with MO. However, no significant differences in acidity were observed in fruit obtained from trees treated with GE alone or with the same concentration of GE and MO in both seasons.

Data presented in **Table 3** shows that all treatments increased total sugars content more than the control. A particular trend in total sugars content was noticed in both seasons, where the higher the GE concentration, the higher the total sugars content.

Total sugars content obtained by GE spray at any concentration and MO did not differ significantly than when GE was sprayed alone.

Results showed that chlorophyll content decreased significantly for all treatments in both seasons compared with the control (**Table 3**). Moreover, chlorophyll content decreased gradually and significantly as GE concentration increased; least values were obtained with 4% GE, especially when sprayed alone.

Most treatments increased anthocyanin content slightly compared to the control but the increment was not significant in the first season. However, in the second season, all treatments significantly increased anthocyanin content than the control. Anthocyanin values increased proportionally with increasing GE concentration. The highest value of anthocyanin was obtained at 4% GE + 2% MO.

The TSS/acid ratio followed the same trend obtained in TSS in both seasons, where all treatments significantly increased the TSS/acid ratio compared to the control. In this respect, the higher GE concentration resulted in a higher TSS/acid ratio.

GE spray at high concentrations appeared to improve both physical and chemical fruit characteristics compared with other treatments. Fruits of control trees harvested after 84 and 78 days beginning from full bloom at 25/4 in 2006 and at 30/4 in 2007 seasons, respectively, while fruits from trees sprayed with 4% GE were harvested after 102 and 94 days from full bloom in the first and second seasons, respectively. A similar trend was obtained in other treatments but varied depending on GE concentration and season.

These results may be explained by the findings of Lopez *et al.* (2007) who concluded that there was a strong correlation between the number of days from full bloom date to reference date, in which fruit size at the reference date increased with an increase in the number of days from full bloom date to reference date. Lott (1965), quoted by Lewallen (2000), mentioned that changes that occur during peach maturation and ripening include a general decrease in flesh firmness, increase in sugar concentration and decrease in acid concentration. Similarly, Seymour *et al.* (1993) suggested that for acceptable peach fruit quality, soluble solids concentration should exceed 10% at harvest.

CONCLUSION

Under the present experimental conditions, spraying 4% GE once in mid-November is a promising treatment for peach trees cv. 'Florida prince' to advance full bloom and harvest

time as well as increase yield, where such cultivar require a period ranged between 94 to 104 days starting from full bloom till harvest to obtain high fruit quality.

REFERENCES

A.O.A.C. (Association of Official Agricultural Chemists) (1985) *The Official Methods of Analysis*, Benjamin Franklin Station, Washington, D.C. USA, pp 490-510

Arispuro IV, Maldonado CC, Tellez MAM (2008) Compounds derived from garlic and bud inclusion agents in organic farming of table grape. *Chilean Journal of Agricultural Research* **68**, 97-101

Botelho RV, Pavanello AP, Pires JP, Muller MML (2007) Effects of chilling and garlic extract on bud dormancy release in Carbernet Sauvignon grapevine cuttings. *American Journal of Enology and Viticulture* **58**, 402-404

Botelho RV, Muller MHL (2007) Evaluation of garlic extract on bud dormancy release of Royal Gala apple trees. *Australian Journal of Experimental Agriculture* **47**, 738-741

Dimitri C, Oberholtzer L (2006) EU and US organic markets face strong demand under different policies. Amber Waves. *Economic Research Service USDA* **4**, 12-19

Hartmann T, Mult S, Suter M, Rennenberg H, Heschbach C (2000) Leaf age-dependent differences in sulfur assimilation and allocation in poplar (*Populus termnla* X *P. alba*) leaves. *Journal of Experimental Botany* **51**, 1077-1088

Hosoki T, Hiura H, Hamada M (1985) Breaking bud dormancy in corms, tubers and trees with sulfur – containing compounds. *HortScience* **20**, 290-291

Hosoki T, Hamada M, Inapa K (1984) Forcing of tree peony for December shipping by pre-chilling and chemical treatments. *Journal of the Japanese Society for Horticultural Science* **53**, 187-193

Hsia CL, Luh BS, Chichester CO (1965) Anthocyanin in free stone peaches. *Journal of Food Science* **30**, 5-12

Koch HP, Lawson LD (1996) *Garlic: The Science and Therapeutic Application of Allium sativum L. and Related Species* (2nd Ed) Williams and Wilkins, Baltimore, pp 37-108

Kubota N, Matthew MA, Takahugl T, Kliewer WM (2000) Bud break with garlic preparations. Effect of garlic preparations and calcium and hydrogen cyanamides on bud break of grapevines grown in greenhouse. *American Journal of Enology and Viticulture* **51**, 409-414

Kubota N, Miyamuki M (1992) Breaking bud dormancy in grapevines with garlic paste. *Journal of the American Society for Horticultural Science* **117**, 898-901

Kubota N, Yamane Y, Toriu K, Kawazu K, Higuchi T, Nishimura S (1999) Identification of active substances in garlic responsible for breaking bud dormancy in grapevines. *Journal of the Japanese Society for Horticultural Science* **68**, 1111-1117

Lavee S, May P (1997) Dormancy of grapevine buds: facts and speculation. *Australian Journal Grape and Wine Research* **3**, 31-46

Lewallen KAS (2000) Effect of light availability and canopy position on peach fruit quality. MSc thesis, Faculty of the Virginia Polytechnic Institute and State University, USA, 34 pp

Lopez G, Johson RS, Delong TM (2007) High spring temperatures decrease peach fruit size. *California Agriculture* **61**, 31-34

Serag El-Deen MMM (2002) Effect of some chemical and natural compounds on growth, fruiting and fruit storability of Thompson seedless grape. PhD thesis, Faculty of Agriculture, Minufiya University, Egypt, 250 pp

Seymour GB, Taylor JE, Tucker GA (1993) *Biochemistry of Fruit Ripening*, Chapman and Hall, London, 464 pp

Shaltout AD (1987) 'Florda prince'. A promising peach cultivar recently introduced to Egypt. *Bulletin of Faculty of Agriculture, Cairo University* **38**, 381-391

Snedecor GW, Cochran WG (1980) *Statistical Methods* (7th Edn), The Iowa State University Press, Ames, Iowa, USA, pp 121-123

Wettstein D (1957) Chlorophyll- letale und Submikroskopisehe Formwechsel Der Plastiden. *Experimental Cell Research* **12**, 427-433